
Space Weather Technical Forecast

Issued on Monday, 20 November 2023 at 01:07 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Increasing Chance of R1. Risk of G1 peaking at start and middle of UTC working week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded by GOES16 and 18 declined to Low in the UTC day of Sunday 19 November, with the largest flare of the period a C7.5 from AR3489 in the southeastern quadrant at 19/0834UTC.

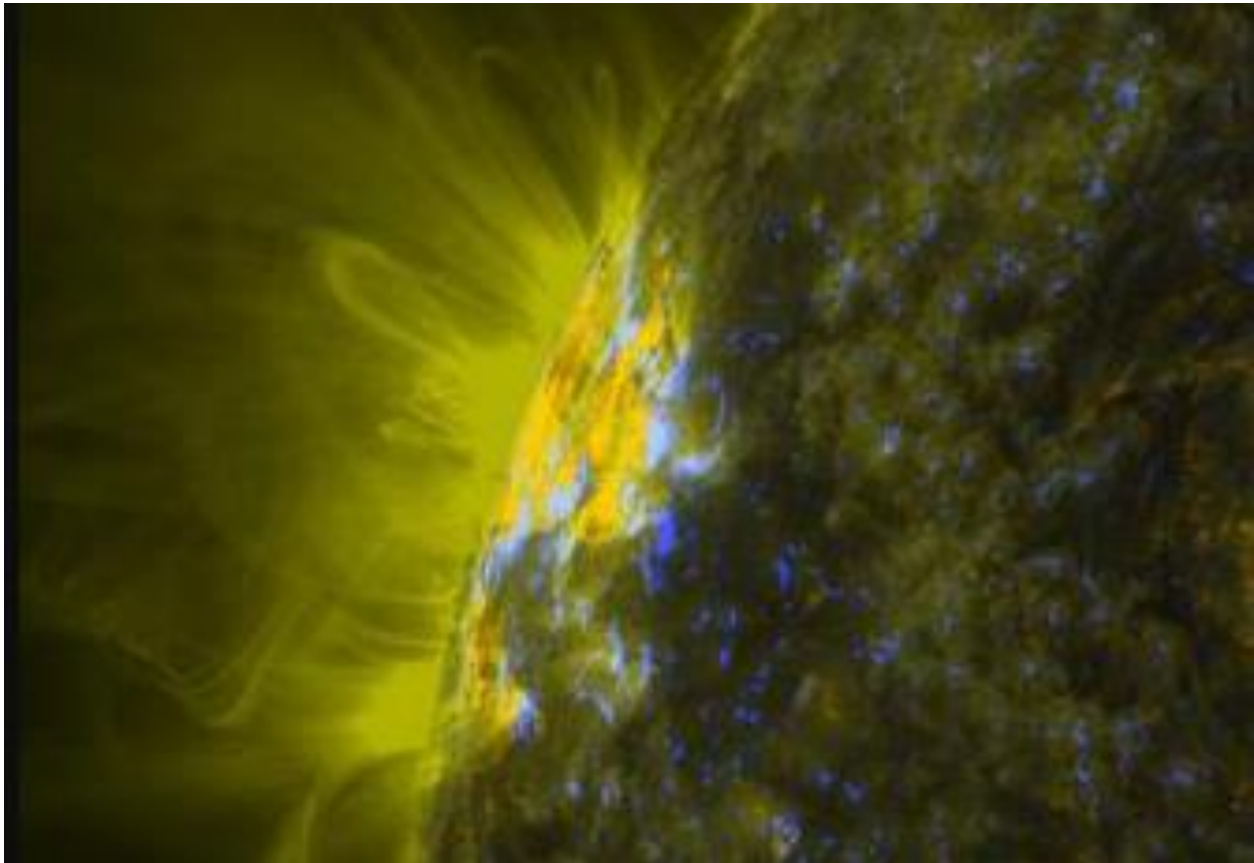


Figure 0: AIA171 and HMIBC composite image from 19/2400UTC showing AR3490 and AR3491 on the northeastern limb.

There are now at least three sunspot regions on the visible disc, with AR3491 attaining a number as a unipolar Hsx/Alpha in the period. The most active group, AR3489, showed a continuing tendency towards proliferation and areal growth of its intermediate regions, but at the expense of its fading trailing spots, such that if trends continue it will become a Zurich Dai from Eai/Beta-Gamma. The 24 hours have also seen tenuous candidates for Mt Wilson delta spots

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within this group, although the tendency of the central spots to spread has not seen these survive long.

While the aforementioned AR3489 was the most active group in the period, this was somewhat against expectations given the presence of a far larger and hitherto more active sunspot region in the northeast - AR3490 - which currently manifests as a $\text{Fai}/\text{Beta-Gamma}$ in looming large on the northeastern horizon. While this appears to occupy a single plage, its large span both vertically and horizontally on the disc may yet be subdivided as further rotation reveals more detail and the links between its constituent parts.

Numerous filament and prominence eruptions were apparent on coronagraph imagery in the period, although the vast majority appeared far-sided or else emanated from the limbs. The one possible exception to this trend that was noted was a small emerging and then erupting filament near S20E030 around 19/0200UTC, from a very similar source to an earlier filament 18/1600UTC. Both have been modelled and are considered to pass below and behind the track of the Earth in its orbit to no effect. No new Earth-directed CMEs were therefore in evidence.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by ACE and DSCOVR at L1, have followed a varying slow regime in the past 24 hours. The solar wind speed rose slightly from 300km/s to peak near 350 around the middle of the UTC day before moderating as the period advanced. The solar wind density was within typical background levels in single figures ppcc throughout, while the IMF was similarly unremarkable at or below 7nT. The north-south component of the IMF, B_z , varied between $\pm 4\text{nT}$ with an erratic character. Finally, the ϕ angle was mainly negative (towards the Sun) throughout.

The net result of the above solar wind measures was for provisionally Quiet geomagnetic activity throughout.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels.

GOES16 high energy (greater than 2MeV) electron flux ranged from Normal Background to Moderate levels, with a peak of 250pfu at 19/1525UTC. The associated 24-hour fluence has declined slightly and remains below the Active threshold ($1\text{e}8$ integrated pfu). The fluence observation at 20/0001UTC was $5.89\text{e}6$ integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: There is a daily Chance of M-class flares from current eastern solar horizon sunspot regions, perhaps rising slightly as a result of a further arrival over the southeastern limb that is now becoming visible from L1 as eastern solar horizon arcing in EUV imagery.

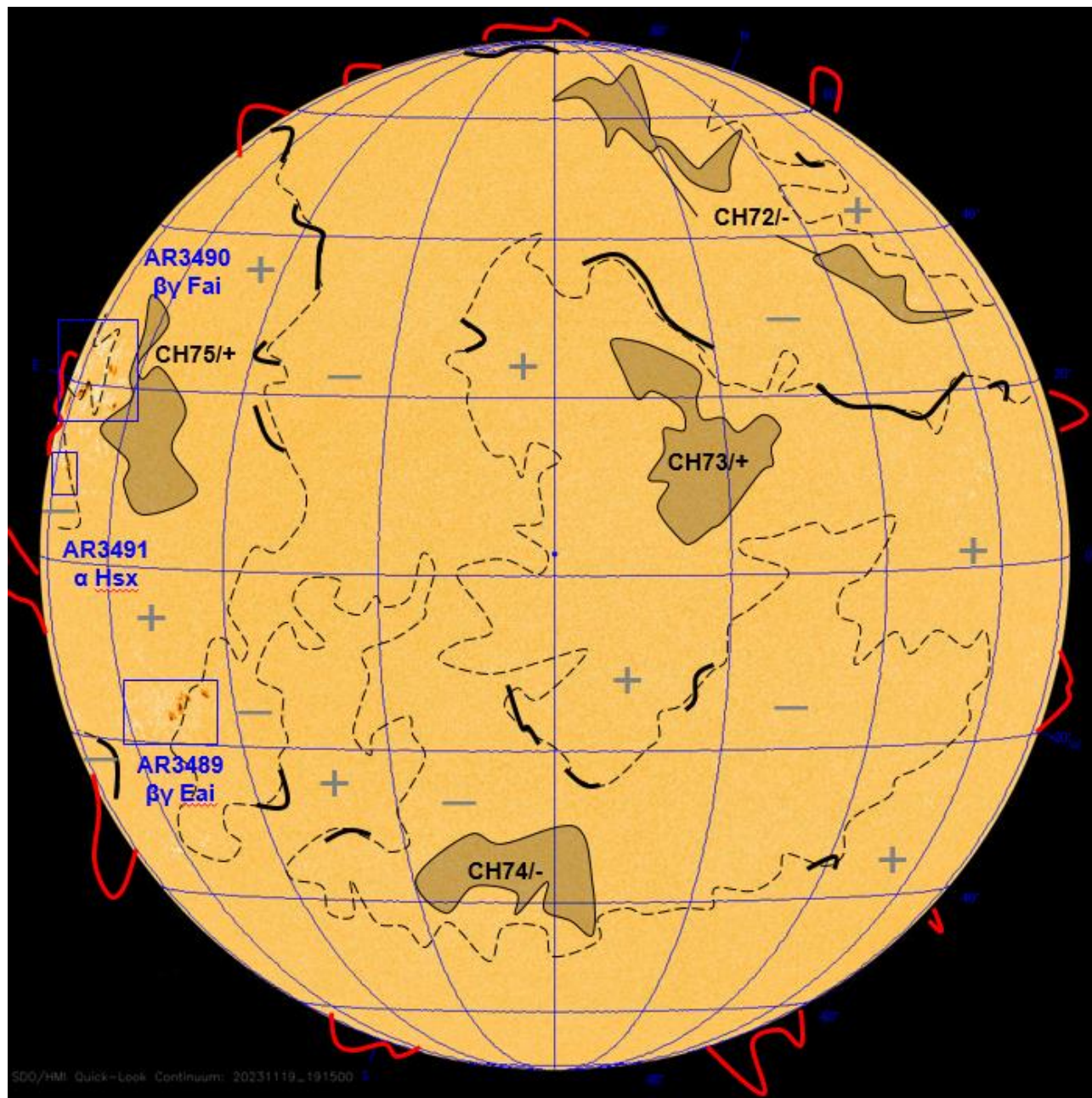
Solar Wind / Geomagnetic Activity: There is one CME in the current forecast - the central filament eruption from 16/0100UTC. This is due within the first 12 hours of the forecast, bringing a Slight Chance of a G1/Minor Geomagnetic Storm. Activity is expected to otherwise be mostly Quiet to Unsettled until the anticipated onset of a coronal hole HSS on Wednesday 22 November, which may see a slightly greater Chance of generating a G1/Minor Geomagnetic Storm.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at Background levels.

GOES16 high energy electron flux is expected to continue to peak at Moderate levels at first, before the potential CME arrival and associated geomagnetic activity suppresses counts at GEO. This suppression may continue with CH73 midweek, before an eventual late-week
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increase once this fast wind's geomagnetic activity lessens. The associated 24-hour electron fluence will most likely remain below the Active (1e8 integrated pfu) level in this four-day period, but with a probable increasing trend into the tail end of the UTC working week.

Figure 1. Solar Analysis Valid 19/1915UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There is one Earth-directed CME that features in the current forecast, the 16/0100 UTC filament eruption from near centre-disc. Despite extensive analyses, the onset time of this feature remains low confidence, although confidence as to a portion of the ejecta lying on the Sun-Earth line is much higher. We are now in a feasible time window for the arrival of the 16/0100UTC CME, however as of yet there is no signal at L1 nor enhancement of ACE EPAM LEMS. Arrival is still considered most likely within the first 12 hours of the current UTC day (Monday 20 November). No new Earth-directed CMEs were observed over the UTC weekend.

The coronal hole-based forecast now comprises just CH73/+, a clear feature currently lying close to the solar equator narrowly in the western hemisphere which is likely to affect Earth midweek UTC. On the previous rotation, this feature was at a similar longitude and produced winds of around 450-500 km/s. This feature is now visually darker and more pronounced on AIA211, and a faster emanating wind is therefore inferred of around 500km/s.

In terms of other potential sources of geomagnetic activity in the forecast that are not yet quantified in the percentages, much of the CME activity seen on available coronagraph imagery over the past 24 hours has been tied to the eastern solar horizon. This is likely to play an increasing role in the risk of geomagnetic activity through the period should activity persist. In addition to this, there are a number of filaments on the disc which have the potential to disrupt and lift-off, perhaps producing Earth-directed CMEs, although there is nothing to imply this is imminent or in progress at the time of writing.

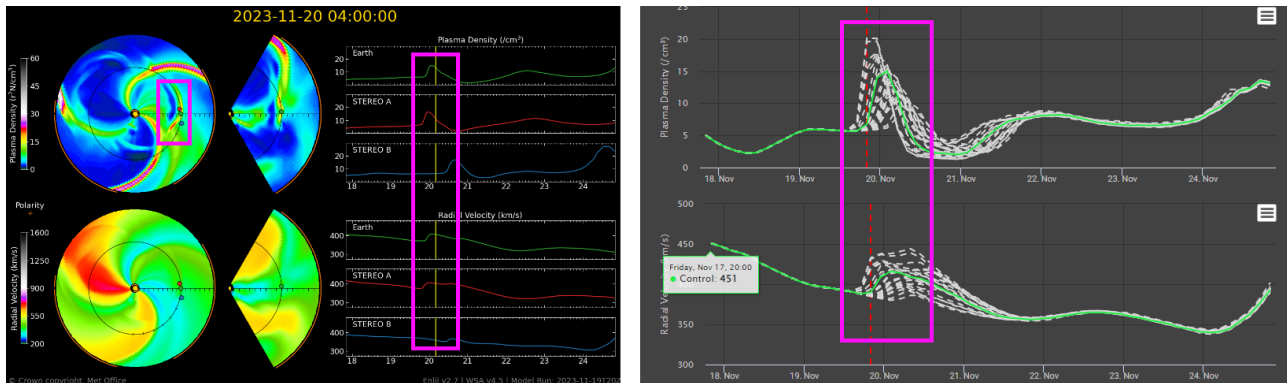
Overall, the geomagnetic forecast comprises a bimodal risk of G1, firstly from the CME within day one, Monday 20 November with a tail into Tuesday; and then an arriving fast wind midweek UTC, again with a tail into the following UTC day.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	20	5	30	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/1100	Partial	Filament Eruption	NW Central	400km/s	First half of UTC day 20 November	Onset time low confidence.

Figure 2: Latest (19/2000UTC) MOSWOC Enlil run and ensemble, which continues to show a large spread in arrival times for the 16/0100UTC CME, although the deterministic's position is felt to offer reasonable guidance as to the most likely onset.



Radio Blackouts - X-Ray Flares:

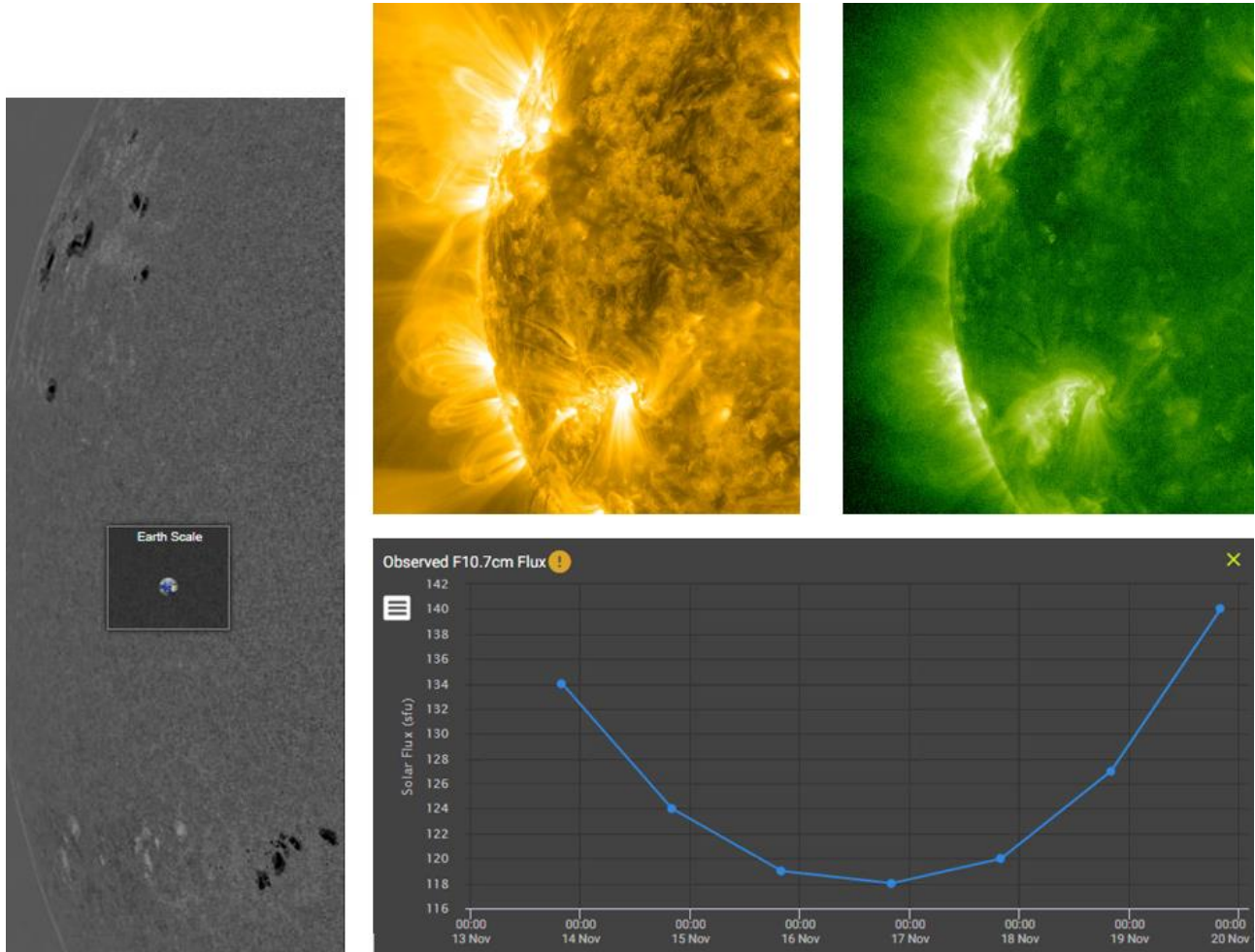
There are currently three regions on the visible disc, all of which lie in the eastern solar hemisphere. Far-sided seismic analysis suggests the approach of one or more new or returning regions over the forecast period, with bright areas beyond the southeastern limb apparent on AIA094 and in the looping of AIA171.

The observed 10.7cm Pentiction flux showed a continued sharp recovery to 140sfu (19 November) in the largest single-day increase since mid-July. This came after values reached a nadir of 116sfu on Thursday 16 November - itself the lowest such value since 29 November 2022 and reflective of the almost spotless disc at that time. This value is expected to continue to increase over the coming days as further regions rotate onto the solar disc across the eastern limb.

All considered, there is a rising Chance of M-class flares given the complex eastern solar horizon and the potential for still more regions arriving here in the first half of the UTC working week. X-class flares are now also considered a daily Slight Chance given the potential in AR3490 in particular.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	50	50	50
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: Clockwise from left: Helioviewer.org-generated image at 19/2400UTC of HMIIF footprint of active regions at current time (black), 24 hours ago and 48 hours ago (both white), showing a vast increase in sunspot populations over this timespan; AIA171 and AIA094 images of eastern limb at 19/2400UTC; Penticton 10.7cm flux over the past week, showing both the lowest value for roughly a year, and now the sharpest increase since midsummer.



Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background levels.

The anticipated arrival of at least one large and complex region over the eastern solar horizon over the coming days has resulted in a relative increase in the risks of a S1/Minor Solar Radiation Storm compared with mid-month. This risk remains nominal until any significant groups approach the western solar hemisphere. There are no significant off-going regions offering any diminishing contribution to this risk.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

High Energy Electrons Event (≥ 2MeV):

Electron flux levels are expected to continue in a similar vein to the UTC weekend at first, having likely reached a steady state in varying between Normal Background and Moderate flux levels. Following the arrival of the 16/0100UTC CME, flux levels at GEO may be briefly suppressed, with this effect probably sustained by any fast wind from CH73, before a late-week (UTC) increase to a peak Chance of Active fluence.

The onset of the 16/0100UTC CME very early in the four-day forecast period is likely to render REFM ineffective as a forecast tool for a time, although its utility should increase significantly as the week progresses.

GEO Electron Environment	Level (cm ⁻² sr ⁻¹ day ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1x10 ⁸	No	1	1	10	30
Very Active	≥ 2 MeV ≥ 1x10 ⁹	No	1	1	1	1